Hexagonal II-VI Structures by Substrate Bandgap Engineering

Brian J. Fitzpatrick and Maria C. Tamargo
Optical Semiconductors, Inc. and City College of New York
8 John Walsh Boulevard
Peekskill, NY 10566-5330 (914)739-0048

The phase transition from cubic to hexagonal as a function of magnesium and sulfur concentration was approximately determined. 12% [Mg] and 8% [S] material, that powder diffraction shows to be hexagonal, has some cubic regions, as is shown by optical crystallography. 8% [Mg] and 6% [S] material, originally thought to be hexagonal, has been confirmed as cubic by optical crystallography, cleavage and the appearance of twins upon intense etching. 16% [Mg] and 12% [S] material is clearly hexagonal. It is unusual to find a very precise value for phase transitions in compound semiconductor systems, so it is unlikely that a much more precise value (than 12% [Mg], 8% [S]) will be forthcoming. Future growth will concentrate on 16% [Mg] material. (Up to now, we have always used a constant Mg/S ratio, to maintain the same lattice constant as ZnSe).

Transmission Electron Microscopy (TEM) has confirmed that the epitaxial layers are indeed hexagonal and epitaxial. This was demonstrated on two orientations, (1120) and another as yet undetermined orientation close to (1010). The ZnSe epitaxial layer was clearly seen, at a thickness much lower than would be expected for cubic ZnSe growth. The quantum well (QW) was not seen. This may be due to the fact that the TEM sample was thick in the observation direction (parallel to the layer), the QW interfaces are not sharp or the many hexagonal twins interfered with the measurement. More experiments are planned, with enhanced knowledge of the diffraction pattern, and on samples that are more definitely hexagonal, and are likely to have no twins. (A maximum twin concentration is expected at the phase transition, where the stacking fault energy goes to zero). A lattice image of the film was taken. No evidence of disturbed interfaces or a high density of defects was seen, but, of course, a TEM sample is a relatively small volume. This work was done at the University of Maryland by Prof. L. Salamanca-Riba.

Thus, we have confirmed the two major postulates of the program:

1) that purely hexagonal material can be achieved by appropriate choice of Mg and S concentrations, and

2) that epitaxial growth of ZnSe in the hexagonal phase can be achieved by using an hexagonal substrate cut in a non-basal plane orientation.

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OPTICAL SEMICONDUCTORS, INC.

8 John Walsh Boulevard • Suite 421 • Peekskill, New York 10566

Laboratory: (914) 739-0048
Office: (914) 762-3009

July 10, 1998

Dr. Yoon Soo Park
Program Officer
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5660

Dear Dr. Park:

This is the third report on Contract N00014-97-C-0367, "Hexagonal II-VI Structures by Substrate Bandgap Engineering". Also included are the DD250 forms, used as an invoice, and the SF298 form, the "Report Documentation Page".

Very truly yours,

Brian J. Fitzpatrick

Brian J. Fitzpatrick

cc: Anna M. Weston,
Administrative Contracting Officer
Program Manager, ONR
Director, Naval Research Laboratory
Defense Technical Information Center
Ballistic Missile Defense Organization

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